Journal of the Nigerian Association of Mathematical Physics
***Volume* 18 (May, 2011), pp 131 - 136**
© J. of NAMP

Geophysical Study of Lithologies Attributes At Isihor Village, Edo State, Nigeria

[1]Ezomo, F.O. And [2]Akujieze, C.N

[1] Department of Physics, Faculty of Physical Sciences,
University of BeninP.M.B. 1154, Ugbowo Benin City, Nigeria.
[2]department Of Geology, Faculty Of Physical Sciences,
University Of Benin, P.M.B. 1154, Ugbowo Benin City, Nigeria

Abstract

Geophysical study of lithologies attribute was investigated in Isihor village of Edo State, Nigeria. These attributes include depth, thickness of lithologies or rock types beneath the sea level or earth's surface. Geophysical prospect of lithologies in this studied area is vital for many economic and environmental reasons for examples a large portion of the world's fossil fuels such as oil, gas and coal are found in stratified (layererd) rock types and much of the world's ground water are store in sediments or stratified rocks.

This investigation actually entailed carrying out electrical resistivity survey of vertical electrical sounding (VES) employing Schlumberger array. Ten(10) VES, fairly distributed in six different stations of Isihor village was carried out. The software IPI2WIN utilizing computer iteration was used for interpretation of apparent resistivity data.

The result of the electrical resistivity survey showed that the lithologies; top soil; laterite, sandy soil, sandy clay loose soil clay soil, and clean sand were intercepted at depths of (0.56-0.86)m, (1.92-13.64) m (12.48-52.78m) (12.58-25.72)m, (*20.04 -74.43)m, (1.20-4.28)m, and (80.76-115.09)m respectively below sea level. Their respective thicknesses were probably 0.56, 0.98m, 7.42m 6.42m, 6.40m, 0.64m and 5.10m. These results agreed very well with available borehole/drillers log records of the area.

1.0 Introduction:

The superiority of electrical resistivity method over other geolectric methods in delineating subsurface lithologies is confirmed by previous work

The ability of the method to furnish detailed information on subsurface lithologies was presented in [8, 9]. Many geophysical exploration methods have been used to locate and delineate subsurface lithological sequences. They are inexpensive and can rapidly provide information about the geological structures and lithologies of a large region under investigation compared to an extensive drilling program which is expensive. The fundamental parameter used in the exploration and description of subsurface rock types by the electrical resistivity method is resistivity. The resistivity of subsurface lithologies depend more on the pore volume including fractures, degree of saturation, weathering and conductivity of the saturant than on the lithology.

Electrical resistivity survey as a viable instrument based on electrical exploration method utilizes electric currents to explore the properties of the earth's interior and to search for natural resources such as water, clay,, oil, coal, shale etc arising from various subsurface lithologies [10].

Previous researchers have proved that the search for oil and social minerals was confirmed to deposit directly observable on the earth's surface in the form of seeps and outcrops or other exposures. When all accumulation in an area that could be discovered by such simple methods had been found, it became inevitable to deduce the presence of subsurface lithologies indirectly by downward projection of geophysical survey information observable on the earth's surface [10,11]. This involves measurements on the sea level that could give information on the structure or composition of concealed lithologies that might be useful for locating desired mineral deposits [6].

Subsurface lithologie are of economics importance for example coal which is one of the lithologies is a major fuel used widely for generating electrical power and heating. Also clay from shale and other deposits supplies the basic material for ceramic of all sorts.

[1]Corresponding author: ***Ezomo, F.O. : E-mail:*** ezomofriday@yahoo.com. Tels +2348054470436

This research paper tends to use geophysics to determine the depths and thicknesses of the various subsurface lithologies in Isihor village of Edo State, Nigeria

BRIEF LOCAL GEOLOGY OF THE STUDY AREA

The study area which is Isihor village in Edo State of Nigeria is underlained by Benin formation [12]. The topography of the area is a plane surface area which has the rock types (lithology); topsoil, laterite, clay sandy clay and clean sand in agreement with the Benin formation which ranges from Miocene to recent [13].

Isihor village is located at about 4.03km away from the university of Benin in Ovia North-East local Government area of Edo State, Nigeria and has latitude and longitude of about $6^0$25'N and $5^0$24'E respectively [14].

EXPERIMENTAL WORK

Vertical electrical sounding (VES) of electrical resistivity method utilizing schlumberger array was employed for this study, detail explanation of the method using the equipment ABEM 300 terrameter and its SAS 2000 Booster have been documented [1-7]

The operational principle of the method leading to the computation of the apparent resistivity ℓ_a formula have been documented in previous research work [2] [3] [4] [5] [6]

The apparent resistivity values were plotted against semi-current electrode spacing (AB/2) , using IP12WINREST software [15]. The resulting set of layer parameters were interpreted in terms of their lithologic equivalent using nearby borehole lithology/ driller's log as a control to obtain layer depths and thicknesses [16].

THEORETICAL ANALYSIS

The basic theory behind electrical resistivity method have been demonstrated in previous research work [2] [3] [4] [5] [6]. In a homogeneous isotropic medium, the potential due to a single point current source such as the current electrode, satisfy laplace's equation arising from the equipontial surface that is clearly hemispherical so that

$$E = -\nabla V \text{ and } J = \sigma E \text{ (Ohms law)} \quad (4.1)$$

$$\therefore\ J = -\sigma\nabla V \quad (4.2)$$

Where $\nabla =$ del operator $= \hat{\imath}\frac{d}{dx} + \hat{\jmath}\frac{d}{dy} + \hat{K}\frac{d}{dz}$ (4.3)

V = electric potential, E = electric field intensity

σ = conductivity, J = Current density.

The mathematical analysis of (4.1), (4.2) and (4.3) which yielded (4.4)

$$\nabla^2 V = 0 \text{ for } r >> 0 \quad (4.4)$$

have been documented [7] where ∇^2 (del squared) is the usual laplacian operator such that

$$\nabla^2 = \frac{d^2}{dx^2} + \frac{d^2}{dy^2} + \frac{d^2}{dz^2}$$

The solution to equation (4.4) may be developed from first principle for a particular earth's model by selecting a co-ordinate system to match the earth's model geometry and imposing appropriate boundary or initial condition. The solution usually yield apparent resistivity (ℓ_a) as a function of the electrodes array namely $\frac{AB}{2}, \frac{MN}{2}$, electric current I and potential difference ΔV

The calculated apparent resistivity (ℓ_a) according to schlumberger array condition of AB $\geq$ 5M N is

$$\ell_a = \pi\left[\frac{\left(\frac{AB}{2}\right)^2 - \left(\frac{MN}{2}\right)^2}{MN}\right]\frac{\Delta V}{I} \quad (4.5)$$

AB = current electrodes spacing in meter, MN = Potential electrodes spacing in meter, ΔV = potential difference in volt I = electric current in Amperes, $\pi = \frac{22}{7}$

RESULTS AND DISCUSSION

The result of the electrical resistivity survey are presented as field curves/computer iterated curves shown in figures 5.1 - 5.6 and lithologies for VES stations shown in tables 5.1-5.6

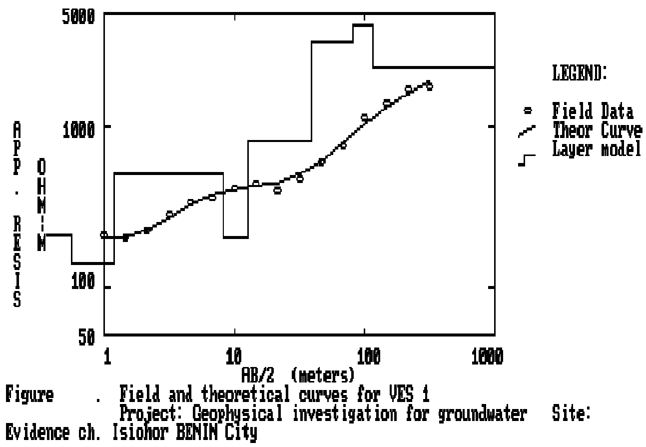

Fig 5.1 Iterated Sounding Curve For VES Station 1

Table 5.1: Lithology for VES station 1

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	209.00	0.56	0.56	Top soil
2	138.99	0.64	1.20	Top soil
3	500.89	7.01	8.21	Laterite
4	198.55	4.61	12.82	Clay soil
5	813.00	26.01	38.83	Laterite
6	3361.00	41.93	80.76	Sandy soil
7	4303.00	34.33	115.09	Sandy soil
8	2336.00	Infinity	Infinity	Clean sand

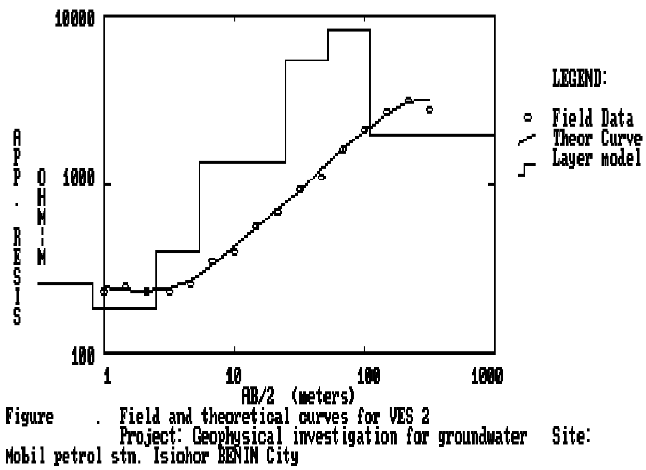

Fig 5.2 Iterated Sounding Curve For VES Station 2

Table 5.2: Lithology for VES station 2

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	256.50	0.82	0.82	Top soil
2	181.00	1.62	2.51	Top soil
3	394.00	2.85	5.36	Laterite
4	1376.00	19.35	24.71	Sandy clay
5	5416.00	27.06	51.77	Sandy soil
6	8048.00	58.06	109.83	Clean sand
7	1990.00	Infinity	Infinity	Clean sand

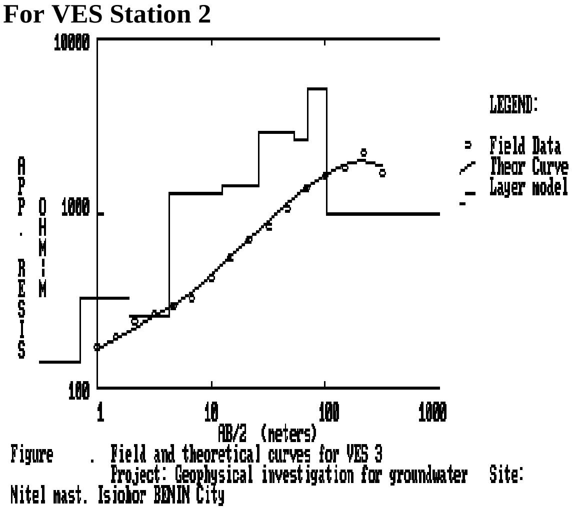

Fig 5.1 Iterated Sounding Curve for VES Station 3

Table 5.3: Lithology for VES station 3

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	141.00	0.71	0.71	Top soil
2	324.00	1.21	1.92	Laterite
3	260.00	2.36	4.28	Clayey soil
4	1310.00	8.20	12.48	Sand clay
5	1455.00	13.24	25.72	Sandy soil
6	2907.00	27.06	52.78	Sandy soil
7	2664.00	16.10	68.88	Sandy soil
8	5250.00	34.33	103.21	Clean sand
9	1009.00	Infinity	Infinity	Clean sand

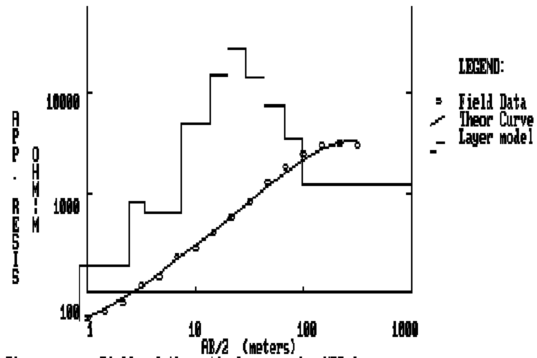

Figure . Field and theoretical curves for VES 4
Project: Geophysical investigation for groundwater Site:
Ine Oil. Isiohor BENIN City

Fig 5.1 Iterated Sounding Curve

Table 5.4: Lithology for VES station 4 for VES Station 4

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	42.67	0.86	0.86	Top soil
2	186.12	1.59	2.45	Top soil
3	788.70	0.98	3.43	Laterite
4	621.11	3.99	7.42	Laterite
5	4994.23	6.22	13.64	Laterite
6	15,452.86	6.40	20.04	Loose sand
7	28014.02	8.87	28.91	Loose sand
8	14,199.97	14.49	43.40	Loose sand
9	7630.89	23.73	67.13	Clean sand
10	3512.61	30.90	98.03	Sandy soil
11	1202.12	Infinity	Infinity	Clean sand

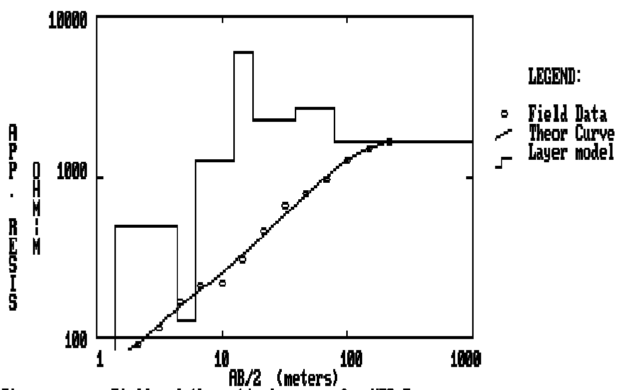

Figure . Field and theoretical curves for VES 5
Project: Geophysical investigation for groundwater Site:
Iyayi Petroleum. Oluku BENIN City

Fig 5.1 Iterated Sounding Curve for VES Station 5

Table 5.5: Lithology for VES station 5

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	61.30	1.40	1.40	Top soil
2	496.00	2.98	4.38	Laterite
3	125.00	1.78	6.16	Clayey soil
4	1285.00	6.42	12.58	Laterite
5	60.00	5.10	17.68	Sandy soil
6	2259.00	20.37	38.05	Sandy soil
7	2635.74	39.83	77.88	Sandy soil
8	1662.12	Infinity	Infinity	Clean sand

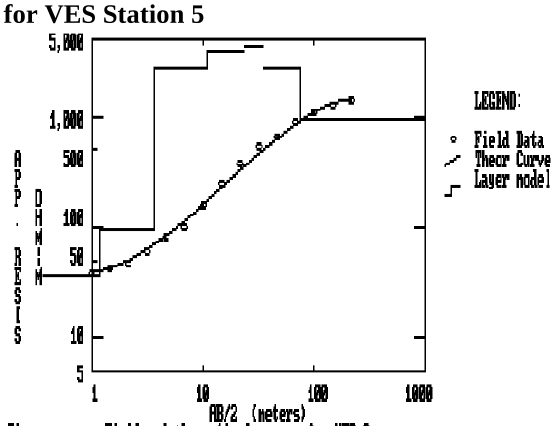

Figure . Field and theoretical curves for VES 6
Project: Geophysical investigation for groundwater Site:
Destiny Motel. Oluku BENIN City

Fig 5.1 Iterated Sounding Curve for VES Station 5

Table 5.6: Lithology for VES station 6

Layer	Resistivity (ohm-m)	Thickness (m)	Cum thickness (m)	Inferred lithology
1	31.73	0.25	0.25	Top soil
2	37.00	0.92	1.17	Top soil
3	94.00	2.48	3.65	Top soil
4	27340.30	7.42	11.07	Laterite
5	3850.35	12.58	23.65	Laterite
6	4384.00	10.95	34.60	Laterite
7	2786.40	39.83	74.43	Laterite
8	933.16	Infinity	Infinity	Clean sand

Table 5.7 Borehole/Driller's log at Isihor (Geo-INFO NIG LTD, (201)1 [16]

Layer	Thickness (m)	Depth (m)	Lithology
1	0.5	0	Top soil
2	8.5	0.5	Laterite
3	15.2	9.0	Clay
4	24.8	24.2	Sandy clay
5	35.4	49.0	Clayey sand
6	48.6	84.4	Sand
7	51.5	133.0	Fire sand
8	64.1	184.5	Sandy clay
9	79.0	263.5	Sand
10	86.6	350.1	Coarse sand

Results of the VES interpretation showed that high resistive layers are limited to stations 4 and 2 shown in table 5.4 and 5.2. The Benin formation is exposed in all the VES stations consisting of the lithologies topsoil, laterite, clay sandy clay, clayey sand, sand, fine sand and loose sand.

A close examination of VES station I revealed a very thick layer of sandy soil lithology of thickness 41.93m at a depth of 80.76m below sea level. This can be of economic value to the community by way of aquifer defection used in the production of potable pure water.

The thickest layer in VES station 2 is clean sand with a thickness of 58.06m at a depth of 109.83m below sea level.

Again thick aquifer is found in VES station 3 which can be also used commercially. In fact the most vital subsurface lithology found in all the VES stations is sandy soil/clean sand which are unconfined aquifer or water-bearing formations because it recharges very rapidly by virtue of its thickness.

Top soil is visible in all the VES stations because it represents upper part of the soil in agreement with Benin formation. It is more fertile than the underlying subsoil which is often stony and lacks organic matter. It can be used for growing agricultural produce and also in sand filling of valley to sea level or earth's, surface.

In general, subsurface lithologies are of economic importance to mankind by virtue of vital natural resources such as oil, Gas water, coal usually obtained from them. The inferred lithologies obtained agreed very well with the Bore-hole/ driller's log at Isihor as shown in Table 5.7 [16].

CONCLUSION

Electrical resistivity survey have demonstrated the usefulness of vertical electrical sounding (VES) for delineating sequences of subsurface lithologies.

The various subsurface lithologies intercepted which are top soil, laterite, sandy soil, sandy clay, loose sand, clayey soil and clean sand at depths of (0.56-0.86)m, (1.92-13.64)m, (1248-52.78)m, (12.58-25.72)m, (20.04-74.43)m, (1.20-4.28)m and (80.76-115.09)m, below sea level are in close agreement with the Benin formation which again is in agreement with the available borehole record of the area. These subsurface lithologies are of economic importance to mankind for development for example are of the subsurface lithologies e.g top soil aids the economy because it is used for agricultural purposes and for growing trees. It is the upper part of the soil which is more fertile than the underlying subsoil that is often stony and lack organic matter. Also clay or mud formed from shale is a source of oil from oil shales for countries lacking petroleum. Again sandstone obtained from sand by moving water or winds is used in building flagstone paving and in the manufacture of whet stones and grindstones etc.

REFERENCES

[1] Ezomo, F.O. and Ifedilis, S.O. (2004): Groundwater exploration in Ekpoma and its environs by electrical resistivity method. Published Ph.D thesis. Physics Dept, University of Benin, Benin City, Nigeria

[2] Ezomo, F.O. and Ifedilis, S.O. (2006); Determination of Water bearing formations at Osasogie quarters by electrical resistivity method. Published M.Sc thesis, physics Dept, University OF Benin, Benin City, Nigeria

[3] Ezomo, F.o. and Ifedili, S.O. (2006): African journal of sciences vol 9, No 1, 21 95-2203

[4] Ezomo, F.O. and Ifedili, S.O. (2005): Journal of Applied Science Vol. 9, N0 3, 6579-6588

[5] Ezomo, F.O. and Ifedili, S.O. (2007): Journal of the Nigeria Association of Math physics, 11 (1), 597-604

[6] Ezomo, F.O. and Akujieze, C.N. (2009); journal of the Nig. Association of math physics 14(1), 177-180

[7] Ezomo, F.O. (2010): journal of the Nig association of math. Phsics 16(1), 597-602.

[8] Ezomo, F.O. (2010); journal of the Nig Association of math physics 17(1), 403-408.

[9] Ezomo, F.O. (2010); World journal of Biotechniology 11 (1), 1662-1667.

[10] Okwueze, E.E. (1996): global journal of pure and applied sciences; 2, 210-211

[11] Maillet, R (1944): Geophysics, 12(4), 529-556

[12] Kogbe, C.A. (1976): Geology of Nigeria, Elizabeth press, first published

[13] Reyment, M.A. (1965b); Aspect of the Geology of Nigeria, Ibadan University Press

[14] Information centre, (2011): palm House, sapele road Benin City, Nigeria –introducing Isihor village

[15] Information from www.cflud.gov/agm/eng/application/subsurface character /613na.

[16] Isihor Borehole/driller's log (2011): courtesy of Geo info. Nigeria Limited

[17] Gibson, P.J. and George, D.M. (2003): Environmental application of geophysical surveying techniques. Non science publishers, Inc New York.